DOCUMENT RESUME

ED 215 385 CS 503 809

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TITLE Sex Differences in the Older Voice.
PUB DATE Apr 82
NOTE 17p.; Paper presented at the Annual Meeting of the Southern Speech Communication Association (Hot Springs, AR, April 6-9, 1982).

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Adults; *Age Differences; *Communication Research; Females; Language Patterns; Males; *Older Adults; *Sex Differences; *Speech Habits
IDENTIFIERS *Voice Qualities

ABSTRACT

A study investigated differences between older adult male and female voice patterns. In addition, the study examined whether certain differences between male and female speech characteristics were lifelong and not associated with the aging process. Subjects were 10 young (average age 30) and 10 old (average age 75) males and 10 young (average age 29) and 10 old (average age 74) females. Each subject completed a series of speech tasks that were audiotaped and analyzed for the following characteristics: hypovalving, hypervalving, vocal tremor, imprecise articulation, loudness, nasality, speech rate, articulation rate, pitch and pitch variability. Results showed significant differences between older male and female voices that do not occur in young males and females. Specifically, greater vocal tremor, softer volume, and increased hypervalving differentiated the older females, while increased imprecision of articulation and expenditure of air in speech tasks differentiated the older male speakers. (FL)

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Sex Differences in the Older Voice

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A paper presented at

Southern Speech Communication Association
Hot Springs, Arkansas 1982

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SEX DIFFERENCES IN THE OLDER VOICE

Sex differences have been studied from a variety of perspectives including such characteristics as physiological, psychological, nonverbal, and communicative style (Eakins and Eakins, 1978). The effects of age on sex differences are increasingly significant because as the American population continues to age, the proportion of the population aged 65 or older continues to expand. Consequently, the study of vocal characteristics in older males and females takes on increasing importance.

The purpose of this investigation was to explore differences between older male and older female voice on perceived and physical paralinguistic parameters of vocal production. Although the primary purpose of this investigation was to discover differences between male and female voices in persons over the age of 65, it was necessary to determine if these differences were significant throughout life or if the differences only occurred with increased age. Consequently, the speaking voices of younger and older males and younger and older females were investigated.

The following hypotheses were formulated for this investigation:

1. There are no significant differences among any of the four groups (young male speakers, young female speakers, older male speakers, and older female speakers) on any perceived vocal characteristic as judged by trained listeners (hypovalving, hypervalving, vocal tremor, imprecise articulation, pitch, pitch variability, rate of speech, rate of articulation, loudness and nasality).

2. There are no significant differences among the groups on any frequency data from the reading task (highest tone produced, lowest tone produced, number of inflections, and maximum change in inflection).
3. There is no significant difference in the percent of fundamental frequency perturbation in the sustained vowel production by any group of speakers.
4. There are no quantitative or qualitative differences among the groups when glottal waveforms are compared (period variability, variability of waveform).
5. There are no significant differences among the groups on any aerodynamic task (vital capacity, air expenditure during interrupted vowels, air volume in syllable repetition).

METHODOLOGY

Although the primary purpose of this study was to determine differences between older male and older female speech patterns, it was determined that certain differences between male and female speech characteristics are lifelong and may not be associated with the aging process. To differentiate between sex differences in speech characteristics which occur in young adults and which occur in the voice of older adults, vocal data from young and older males and females were analyzed for both sex and age effects.

Subjects

Twenty males and twenty females participated in the study. Ten males were considered representative of the young adult age group with an age range from 23 to 32 (mean age 29.8 years) while ten older males ranged in age from 68 to 81 years (mean age 74.5 years). Ten females who formed the young female group with an average age of 29 years, ranged in age from 21 to 32 years. The ten older females with an age range from 69 to 82 years had an average age of 73.6 years.

Each participant in the study was a nonsmoker with no observable

speech disorders. Furthermore, each participant demonstrated hearing thresholds expected for his/her age (Lebo and Reddell, 1972) and was not taking medication known to affect speech characteristics such as fundamental frequency or articulatory ability.

Procedures

Each subject participated in the study between noon and 3 p.m. in order to control vocal variation due to time of day. Each speaker's voice was recorded on an Ampex tape recorder model AG 500-2 in conjunction with a 802 Ampex microphone. A 6-inch mouth to microphone distance was maintained as the speaker read the first paragraph of the "Rainbow Passage " (Fairbanks, 1960) with normal conversational loudness and pitch.

An audio tape recording was made as each subject sustained the vowel /a/ for seven seconds while holding constant vocal effort and monitoring intensity on a VU meter. The subject repeated the sustained vowel task at a loudness level judged to be twice as loud as normal.

During the sustained vowel tasks, a display of glottal activity was made by electro-laryngographic waveform recording. The electro-laryngograph is an instrument developed by Fourcin at the University of London to measure vocal fold activity by means of a noninvasive technique which uses electrical impedance to produce an analogue signal for display. A low impedance high frequency oscillator electrode was placed lateral and superficial to the subject's thyroid cartilage while the other similarly placed electrode was connected to a low output impedance current detector. This method provided an analogue signal which is displayed as a glottal waveform corresponding to the opening, closing, and closed phases of vocal fold vibration (Fourcin, 1974; Fourcin and Abberton, 1972, 1979).

The subject was asked to complete aerodynamic maneuvers in a random ordered sequence. A Wedge Spirometer model 570 was connected to a Honeywell

Visicorder lightbeam oscillograph model 1508 for graphic display of air volume displacement. Each subject produced the maximum number of interrupted /a/ vowels as he/she could on one breath. Each subject also produced the maximum number of /z/ and /s/ syllables on one breath. All repetition tasks were at normal conversational pitch and loudness and speech was produced at the rate of two to three vowel or syllable productions per second. Vital capacity maneuvers were also accomplished for each speaker.

Measurement

Twelve graduate sutdents trained in the use of the Wilson Voice Profile (Wilson, 1971) rated the recorded readings of the "Rainbow Passage" on a modified Wilson Voice Profile form. The ratings provided the perceived differences among the voices on the following characteristics: hypovalving, hypervalving, vocal tremor, imprecise articulation, loudness, nasality, rate of speech, rate of articulation, pitch and pitch variability. These characteristics have been identified as occurring in older voices and in differentiating male and female voices (Ryan and Burk, 1974; Hartman and Danhauer, 1976; Ptacek and Sander, 1966).

The readings of the "Rainbow Passage" were applied to a Tektronix 6087 Visipitch which provided a display of the fundamental frequency contour during reading. A cursor device provided a digital readout at any point of the displayed contour. The highest and lowest frequencies produced in reading, the number of inflections, and the maximum change in inflection were calculated from this display.

A two-second midportion of the sustained vowel /a/ was applied to the Honeywell model 120 accudata DC amplifier. This output was applied to a Honeywell M16-50 light-beam galvanometer to produce the oscillographic form of the speech signal on light-sensitive paper. The display was examined for fundamental frequency perturbation following Lieberman (1963). Any

perturbation or cycle which varied from adjacent cycles by .5 msec or greater was considered significant.

The electro-laryngographic waveform of the midsection of the sustained vowel was also displayed for each subject. Measurement of the period of vibration could be accurately calculated to confirm the previous perturbation measurements. In addition, qualitative judgments concerning the variability in waveform shape were also made.

Finally, the Visicorder display of the Wedge Spirometer air displacement was measured. The average volume of air expended in each syllable and vowel production task as well as estimates of vital capacity were found.

RESULTS

An average intrajudge reliability of .91 and interjudge reliability of .93 were found for the ratings of perceived vocal characteristics. Reliability of physical data measurement was also high with less than 0.05% interjudge error.

Perceptual Results

The expected significant difference in perceived pitch between male and female voices was found in both young and older speakers. Although no other differences between young male and young female voices were found, the older male and older female groups were significantly different from the other groups on several perceived vocal characteristics. The analysis of variance for hypervalving, vocal tremor, hypovalving, imprecise articulation, and loudness yielded significant interactions. Follow-up analyses showed significant differences among the groups on these characteristics. Although the older male group was significantly different from the young male group on perceived hypovalving, there was no statistical difference between the

older male and older female group on this factor. The older males were significantly different from the older females as well as the younger speakers on the factor of imprecise articulation. The older females were perceived as displaying more hypervalving and vocal tremor and less loudness than the other groups. Table I presents the cummulative rating for each group on the five significant vocal characteristics.

TABLE I

Perceptual Characteristics
(ratings in parentheses)

hypovalving	YM (1.2)	OF (3.7)	YF (5.1)	OM (7.0)
hypervalving	YF (1.4)	YM (3.6)	OM (5.3)	OF (9.9)
vocal tremor	YM (0.0)	YF (0.2)	OM (1.4)	OF (5.1)
imprecise artic.	YM (0.2)	YF (0.1)	OF (1.9)	OM (5.6)
loudness	OF (-5.2)	OM (-1.1)	YM (-0.9)	YF (0.0)

*nonsignificantly different groups are connected by underlining

Frequency Results

The analysis of the frequency data from the reading passage provided the expected sex differences in pitch ($F(1,36)=240.69$, $p<.001$), highest tone produced in reading ($F(1,36)=113.9$, $p<.001$) and lowest tone produced in reading ($F(1,36)=403.85$, $p<.001$). There were significant differences in the

number of inflections as well as the maximum inflection produced between the younger and older groups but no difference occurred between the males and females on these variables.

The analysis of variance with age and sex as the between subjects factors yielded significant simple effects for sex ($F(1,36)=13.61$, $p<.001$) and age ($F(1,36)=21.46$, $p<.001$) on the fundamental frequency perturbation variable. Percent of perturbation was significantly increases in male voices compared with female voices and was increased in older voices compared to younger voices. Table II presents the average percent and standard deviation of perturbation for each of the groups.

TABLE II

Average Percent of Fundamental Frequency Perturbation
(standard deviation in parentheses)

Group	Average Percent	Standard Deviation
YM	4.56	(2.83)
YF	0.79	(0.98)
OM	14.44	(8.75)
OF	6.09	(3.91)

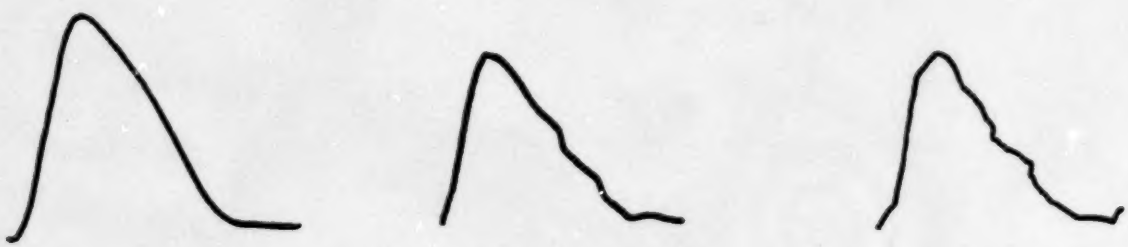
Electro-laryngographic Waveform Results

Measurement of electro-laryngographic wave form period confirmed the fundamental frequency perturbation data. Not only did the older speakers produce more perturbation than the younger speakers, but the males displayed greater wave form period variability than females.

The qualitative analysis of the waveforms suggests that waveforms produced by older speakers are somewhat more variable in shape than are the waveforms produced by younger speakers. The older male speakers generally have numerous instances of minor fluctuations in the shape of the decending waveform (that which corresponds to the opening phase of the vibratory cycle). The older female speakers also have variations in shape of the waveform. Although the waveforms produced by the older females are not as smooth as those of young adult speakers, they do not show the excessive variation seen in the abducting or opening phase of older males. See TABLE III for a composite of typical waveforms of young speakers, older females and older males.

TABLE III

Typical Electro-laryngographic Waveforms



Young Adult | Older Female | Older Male

Aerodynamic Results

All analyses of variance for aerodynamic measures produced significant interactions. Follow-up analyses of wholey significant different comparisons

yielded the results found in Table IV. Comparisons of young male and young females on vital capacity measures yielded significant differences as did the vital capacity comparisons between older males and older females. Vital capacity in females is significantly reduced when compared to males of the same age.

The amount of air expended in the interrupted vowel task was significantly greater in the older male group compared to the older female group. The older males expended significantly greater volumes of air in producing forceful vowels than every other group. On the production of fricative syllables, /sʌ/ and /zʌ/, the older males not only expended more air than the older females, they also expended more air than the younger speakers.

TABLE IV

Aerodynamic Measures*
(mean volume in parentheses)

Vital Capacity (in liters)	OF (2.34)	OM (3.25)	YF (3.37)	YM (5.10)
Interrupted Vowels (in CC)	OF (40.4)	YM (46.2)	YF (53.25)	OM (91.95)
Forceful Vowels (in CC)	OF (59.4)	YF (68.4)	YM (71.9)	OM (127.7)
/sʌ/ syllable (in CC)	OF (88.16)	YF (107.13)	YM (120.91)	OM (171.2)
/zʌ/ syllables (in CC)	OF (64.76)	YF (75.09)	YM (88.50)	OM (135.42)

*nonsignificant means are connected by underlining

DISCUSSION

The results of the present investigation suggest that certain vocal characteristics such as pitch and vital capacity differentiate males and females through out life. Other characteristics do not differentiate between young adult male and female speakers but are associated with either older male or older female voices. These differences are not only perceptually significant but can be objectively quantified.

This study has found significant differences between the perceived voices of older males and older females which are not perceived differently in younger male and female voices. Older males are perceived as displaying greater hypovalving and imprecise articulation than the older females while these differences do not differentiate younger males from younger females. The increased air expended in vowel and fricative syllable production by older males supports the perception of hypovalving and imprecise articulation. Hypovalving is associated with breathiness accompanying weak glottal closure, and imprecise articulation may be associated with excessive air loss during the production of vowels and fricative syllables which depends upon fine adjustment of the articulatory mechanism to create the sharp turbulance we perceive as fricative phonemes. Since this increase in hypovalving and imprecise articulation is only perceived in older males, these characteristics suggest that age may affect the male vocal patterns in a unique way. It is possible that age affects the ability to make the rapid, fine adjustments of the speech mechanisms. If that is the case, the older females should also show signs of reduced control. Since the older females are not perceived as hypovalving nor as displaying imprecise articulation, we have two possible explanations for these results. First, age may affect the older females'

control as it does the older male, but the older females have employed compensatory skills to overcome the slight loss of control. The second explanation is that there is indeed a difference between older male and older female vocal production due to different aging processes which occur to each sex. Indirect support for either explanation is available but no conclusive data have been found.

Although there are no differences between young males and females on the characteristics of hypervalving, vocal tremor, or loudness, older females are perceived as significantly different from older males and even from the younger adult speakers on these variables. It is tempting to assume that aging has contributed to the differences in the older females' perceived voice. Vocal involution and physiological changes of the laryngeal structure occur at an earlier age in females (Luchsinger and Arnold, 1965). Other explanations may include the "set" of the older female in the testing situation. The desire to perform to the best of her ability may account for the increase in tension which is perceived as hypervalving and/or vocal tremor. The increased tension in the older female voice could also be due to the need to compensate for deteriorating control of the fine adjustments necessary for speech. These compensatory strategies and associated tension are not found in older male speech. Another explanation includes cohort affects which may account for the significant decrease in loudness in older female voices. These older women were raised in a social era which valued the soft spoken woman. This cultural artifact may contribute to the resulting soft voices of the older females. The variable of hearing loss was controlled in this study so differences in vocal volume should not be due to differences in auditory sensitivity.

As expected, there were significant differences between males and females in both age groups on the frequency characteristics of voice (i.e., fundamental frequency, highest tone, and lowest tone are significantly higher in females and lower in males). Surprisingly, there was not a sex difference between the number of inflections nor in the maximum change in inflection between the vocal reading styles of males and females. One would expect females to produce more and greater intonational variation in reading since women use inflectional patterns to express politeness (Lakoff, 1973) and young girls use more expressive intonation in storytelling than young boys (Key, 1975). These recent studies suggest greater variability in the female voice during speaking. The present study confirms the study which found superior female speakers had less pitch variability than superior male speakers in oral reading (Snidecor, 1951). Neither the judges' perception of pitch variability nor the objective measures of inflection showed statistical differences on the sex effect. Instead, the increase in inflectional variation appears to be related to increased age rather than differences in sex.

Fundamental frequency perturbation was significantly increased in males compared to females. Leiberman (1963) suggested that greater absolute perturbation would be associated with longer period of vibration (the lower fundamental frequency in males), but this study established that an increase in the percent of perturbation also occurs in the male group with lower fundamental frequency. The significant age effect establishes that fundamental frequency perturbation is increased with age. This is unfortunate since increased fundamental frequency perturbation is indicative of laryngeal pathologies such as cancer, polyps, and other pathological growths. Thus, fundamental frequency perturbation can not be used as a sensitive device for detecting laryngeal pathology in older persons.

The electro-laryngographic data support the fundamental frequency perturbation analysis. More variation in waveform period is associated with males than with females. Whereas the fundamental frequency analysis used the acoustic signal as the basis of measurement, the electro-laryngograph analysis was based upon the analogue signal display of vocal fold activity. Not only is the period of the waveform more variable, but the waveform shape also shows greater fluctuation in older male voices. Minor irregularities in the long opening phase of older male waveforms may contribute to the perception of hypovalving in older male voices. The older males also expend greater volumes of air in producing interrupted vowels which are controlled at the laryngeal level. The long, irregular opening phase in the older male waveforms can be associated with these measures of excessive air usage. The qualitative analysis of the electro-laryngographic data, the observable variation in waveform shape in older male phonation, is supported by judges' ratings as well as objective physical quantitative measures.

Finally females produce significantly smaller vital capacity volumes than males of the same age. With age, the vital capacity of both males and females is reduced. Even though the air supply is reduced in both older males and females, the older females expend less air in typical speech tasks. The older males with reduced vital capacities, expend greater amounts of air in the same normal speech tasks. This is especially significant since older males have relatively less control of air expenditure on forceful speech productions. As the older male taxes his speech system to produce loud interrupted vowels, he expends even greater volumes of air. Since the mid-lung volumes are used for speech, the reduction of available air supply should not affect the daily speech production of the older male. But as control of air expenditure

lessens or as the system is taxed with the need for more forceful productions, it is possible that he will experience difficulty at the end of longer utterances. Breath control activities which develop laryngeal and articulatory strategies may become necessary.

SUMMARY

There are significant differences between older male and older female voice which do not occur in the young male and female. Although these differences may be attributed to cultural artifacts or cohort effects, differences in the biological aging process may contribute to this sex difference. We, as communication specialists, must deal with the changes in the voice and speech support systems of older adults.

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